SOLUTION

Select reasonable operating pressures for a freezer that uses R134a. The inside compartment of the freezer should be maintained at -5 C. In the worst case scenario, the freezer will be left out in the garage in the summer where the temperature reaches a maximum temperature of 35 C. Assume that you need at least a 5 C temperature difference in order to have effective heat transfer.

1) Is the evaporator inside or outside the freezer? What is the operating pressure?

Inside

$T_{evap} = -10\ C \rightarrow P_{sat} = 201.7\ kPa$

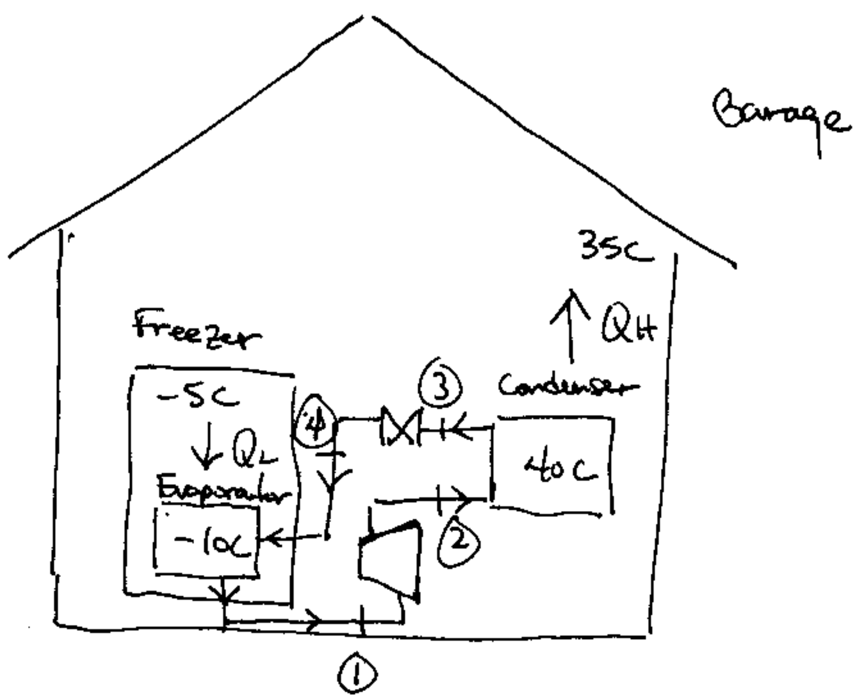
2) Is the Condenser inside or outside of the freezer? What is the operating pressure? Since our superheated vapor tables listed according to pressure use the next higher pressure for which we have a table.

Outside

$T_{condenser} \sim 40\ C \rightarrow P_{sat} = 1017\ kPa$

Selected $P_{condenser} = 1000\ kPa$

3) Bad insulation allows heat into the freezer compartment at a rate of 400 W. This heat load has to be removed by our freezer (refrigeration cycle). Calculate the amount of work that the unit requires in Watts. The evaporator temperature is -10 C and the condenser pressure is 1.0 MPa. The compressor has an isentropic efficiency of 90%



* R134a *

State 1 (Sat Vapor)

$P_1 = 201.7$ kPa

$T_1 = -10C$

$x_1 = 1$

$h_1 = 392.28 \frac{kJ}{kg}$

$s_1 = 1.7319$ kJ/kg K

State 2

$P_2 = 1000$ kPa

$h_{2s} = 425.7$ kJ/kg

(Interpolate)

State 3 (Sat Liquid)

$P_3 = 1000$ kPa

$x_3 = 0$

$h_3 = 255.6$ kJ/kg

(Interpolate using Saturated R134a Temperature Tables)

State 4

Throttling Valve

$P_4 = P_1$

$h_4 = h_3 = 255.6$ kJ/kg

$$\eta_c = 0.9 = \frac{h_1 - h_{2s}}{h_1 - h_{2a}} \qquad h_{2a} = 429.4$$

$$w_c = h_1 - h_{2a} = -33.42 \text{ kJ/kg}$$

$$q_L = h_1 - h_4 = 136.68 \text{ kJ/kg}$$

$$\dot{Q}_L = \dot{m} q_L = 0.4 \text{ kW} \qquad \dot{m} = 0.00292 \text{ kg/s}$$

$$\boxed{\dot{W}_c = \dot{m} w_c = -97.8 \text{ W}}$$

$$COP_R = \frac{\dot{Q}_L}{\dot{W}} = \frac{400 \text{ W}}{97.8 \text{ W}} = 4.09$$